passenger feels as if he were in a vessel floating upon the waves. Nevertheless the invention of this species of bridge required great genius and an iron will; and if the principle be not adoptable for bridges in general, we have learnt what can be done in case of need. You will remember the accidents which have arisen upon such constructions, from the uniform motion of the marked step of soldiers, or from even less noticeable causes of the fracture of these bridges. After mentioning the passages over the Thames, I must speak of that below it—the tunnel, invented by the elder Brunel, and executed by him between 1825 and 1843. Five times did the water interrupt the works, but the perseverance of Mr. Brunel was crowned with success, and a communication between the two banks of the river was established below its bed. In contemplating this surprising construction, I was astonished that the bold and ingenious mind of its creator had not preferred the cylindrical system with a single tube, to that of two circles united in a square, for the construction, and iron to brick, for the materials. If I am rightly informed that the diameter and depths were prescribed to the projector, and that the exorbitant price of iron at that time forced him to employ brickwork, still, I suppose that had the cylindrical system in ironwork been adopted, the works would have advanced with much greater rapidity, and the construction would have been much more solid; because the inconveniences arising from an inconstant temperature, which are very great in iron constructions, placed in the open air, could not have been much feared at this depth below the general level of the ground. It is remarkable that Brunel constructed a tunnel in brick below, and Stephenson a tunnel in iron above, the earth. Probably, these will remain unique specimens in their way. For myself, I very much fear that the wind and vibration of the air, from the passage of the trains, will break the rivets of this last work, without counting the moment of danger when the material strength of the iron shall have expired. But always, and in every case, the spectators after a battle believe themselves to be greater captains than Scipio or Hannibal, and there can be no doubt that Brunel was, and that Stephenson is, a man of genius."

SERVAAS DE JONG.

MINERAL PRODUCTS RELATING TO THE BUILDING ARTS IN CLASS I. OF THE GREAT EXHIBITION.†

BUILDING STONES OF THE MILLSTONE GRIT.

THE geological formation known under this name forms a part of the carboniferous series, and, like the mountain limestone, is developed in all our coal fields, although very variable both in its thickness and structure. Thus, in Derbyshire, the millstone grit consists of several hundred feet in thickness of very pebbly quartzose gritstones, interstratified with finer sandstones and shales, and occasionally with beds of thin bad coal.

In the more northern parts of the same coal field the millstone grit reaches to 1,000 feet in thickness, and consists of three principal divisions of coarse, quartzose gritstones, separated by shales and by flaggy, finer grained, and freestone grits; containing also beds of chert, thin limestones, ironstones, and a few coal seams. In the South Wales coal field the millstone grit about Pontypool does not exceed 200 feet in thickness, but increases towards Merthyr, where its thickness is 330 feet. In the Forest of Dean the sections of the Ordnance survey give a thickness of about 270 feet. In these coal fields it consists of red and grey gritstones, and conglomerates inclosing white quartz pebbles alternating with thin beds or partings of marl. In the Bristol coal field the thickness is about 1,200 feet, and consists, in the upper parts, chiefly of very hard beds approximating to quartz rock; in the lower part, of soft, laminated, and shaly sandstones, also of some beds which are ferruginous; and a seam of coal occurs about 400 feet from the base. Few of the beds of millstone grit in the Bristol coal field possess the valuable properties of the millstone grit in the north of England. This has always been a favourite stone for large engineering works, and has been extensively employed both in Waterloo and London bridges, where the arches, spandrils, and parapet are of granite, but the piers up to springing height, or the level at which the arches commence, are built of millstone grit, probably Bramley Fell, or other Yorkshire stone.

The specimens of millstone grit in the Exhibition are from the neighbourhood of Berwick-upon-Tweed, Hartford Bridge Northumberland, several from the neighbourhood of Leeds, Elland Edge, Barnsley, Sheffield, and other parts of the great midland coal field, and one specimen from the Bristol coal field. The stone from Berwick-upon-Tweed is a whitish coloured very strong grit, belonging to the coal field of that district, and was employed in building the Royal Border Bridge at Berwick. This specimen may be taken as the representative of many excellent gritstones in the county of Northumberland, which are well adapted for building purposes, and may be used as millstones both for grinding corn and for crushing as in cider-presses. The price of these Northumberland gritstones, delivered in London, would not exceed 1s. 8d. to 2s. per cubic foot, according to the size of the blocks; and as the price for dressing them by the local masons very little exceeds that for Portland stone, it is probable they might be introduced with advantage into the London market.

No. 136 is also a specimen of the Northumberland gritstone, namely from Hartford Bridge, near Morpeth. This stone is said to be of remarkable density, and to be capable of resisting the weather to an extraordinary degree. The bridge at Hartford, which is built of this stone, is said to be 600 years old, and the marks of the chisel are still visible on the stone. It has been used of late years for building Miss Burdett Coutts' new church in Westminster, and for improvements at Windsor Bridge. The specimen exhibited represents a bold, deeply cut carving of the Earl of Carlisle's coat of arms, and shows the capability of the stone for carrying a fine edge, and being carved in the most intricate forms. It is a very strong quartzose grit, of a uniform light grey-brown colour.

The millstone grits from the neighbourhood of Leeds are well represented by several specimens from Meanwood quarries, included in Nos. 160, 171, and 183, and by a specimen from Fairhead included in No. 190. The Meanwood stone varies from a somewhat fine crystallisation to a rather coarse conglomerate, enclosing both angular and rounded pieces of quartz with argillo-silicious cement, slightly micaceous, and sometimes containing a few ferruginous specks. The colour a light yellowish brown. This stone has been extensively used in her Majesty's dockyards and in Dover pier, is in high estimation for marine engineering, and considered a very valuable stone where large blocks are required. It is admirable for heavy copings of retaining and parapet walls, for dock and lock gates, &c. It is extensively used as a millstone, and for the foundations of heavy machinery, being equal in strength and durability to the best Bramley Fell stone, from which it does not materially differ in composition. The Meanwood quarries attracted the attention of the commissioners appointed by her Majesty to enquire into the best stone for the new Houses of Parliament. They report the weight per cubic foot as 140 lbs. Beds from 2 to 10 feet thick,—blocks of great size may be procured; price at quarry 10d. per cubic foot for squared blocks of 1 ton to 1½ ton weight; carriage by land to Leeds 2d. per foot; price of plain work to face 10 per cent. higher than for Portland stone. Now that we possess the benefit of railway competition between this part of Yorkshire and the metropolis it is probable that this stone can be brought to London, and sold at a profit for about 1s. 6d. per cubic foot. This, it must be understood, will prove a great advantage wherever a first-rate stone is required. Of late years, the original Bramley Fell quarry has been nearly exhausted; so that, in place of the celebrated Bramley Fell stone, builders have either had recourse to granite, a much more expensive material, or have been driven to the use of a reddish-coloured ferruginous gritstone, very inferior to that from the original Bramley Fell quarries on the Leeds and Liverpool canal. For some reason or other (probably owing to the presence, in greater abundance, of the red oxide of iron), the red-coloured ferruginous stones never stand the weather so well as the grey and brown varieties of the millstone grit. The specimen from Fairhead (No. 190) is a light greyish brown stone, with quartz grains moderately coarse, argillo-silicious cement, a few small plates of mica, and occasionally small ferruginous spots. It is procured from quarries in the parish of Grosmont, in the Vale of Esk, North Riding of Yorkshire, and squared scabbled blocks of it can be supplied in London at 1s. 4d. per cube foot, or in dressed blocks at 1s. 6d. to 1s. 9d. per foot, according to the description of work. There are two other stones from Leeds which may also be classed among the millstone grits, both exhibited by Messrs. Freeman under No. 160, namely, one from Horsforth Quarry, said to have been used in her Majesty's dockyards, Dover pier, &c.; this is a very coarse quartzose grit, containing large fragments of white angular quartz: the other specimen is from Gipton Wood, and is not very unlike the Horsforth stone.

The Elland Edge stone is a light, greyish brown variety, with moderately fine grains of quartz, an argillo-silicious cement, and small plates of mica in the planes of the beds—weight per cubic foot 153 lbs. 4 oz. No. 22 of objects outside the building at the west end contains an assortment of Sheffield grinding stones of various sizes from Ardsley Oak Quarry, near Barnsley. These stones, like others of the same series, consist of quartz grains united by an argillo-silicious cement, but the grains are of a more uniform structure, and offer a more uniform resistance than in those varieties which are unfit for grinding purposes. They are almost devoid of the very hard pebbles of white quartz which prevail in some beds, the grains being generally of a light greyish brown colour. The Barnsby and Sheffield grindstones are used not only throughout the neighbourhood, but all over England, and in many parts of the continent for grinding tools of various descriptions. No. 45 contains a collection of millstone grits and grindstones from the neighbourhood of Sheffield, namely, from Bull Head Quarry and Reeve's Edge Quarry. These both appear to be good stones, that from Reeve's Edge having the coarsest grains, and both may be described as light greyish brown-coloured stones.

The Darley Dale stone, exhibited as part of No. 160, is a well known variety from Stancliffe Quarry. This is a coarse-grained strong quartzose stone, with grains of moderate size and decomposed felspar, with an argillo-silicious cement, ferruginous spots, and plates of mica. Colour, light ferruginous brown. This stone is capable of being turned in a lathe, and was used in the erection of Darley Dale Abbey, Stancliffe Hall, St. George's Hall Liverpool, the Birmingham Grammar School, several of the neighbouring railway stations on the Midland and other lines, Lismore Castle in Ireland, a theatre in Manchester, the Waterworks at Salford, and Mr. Beaufoy's schools in Lambeth. It is described by the Building Stone Commissioners as occurring in blocks of very great size to a depth of 200 feet, weight 145 lbs. per cubic foot. Price in London, 3s. 3d. per foot; cost of face work 30 per cent. above that for Portland stone; but it is probable that these prices would be much lower now in consequence of railway communication which has been completed since the Commissioners made their report. The last specimens we shall notice from the Midland coal field are those from Wingerworth Quarry, near Chesterfield (No. 192). One of the specimens much resembles the Bramley Fell stone from Yorkshire. They are all of a light brown colour, and appear well adapted for building purposes.

The millstone grit of the Bristol coal field is

* To be continued. † See p. 906, ante.

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